

CAR NUMBER PLATE RECOGNITION

By

SAIFUL HELMI BIN ABDUL HAMID

FINAL PROJECT REPORT

**Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)**

**Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan**

**© Copyright 2007
by
Saiful Helmi Abdul Hamid, 2007**

CERTIFICATION OF APPROVAL

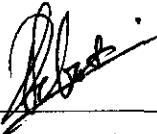
CAR NUMBER PLATE RECOGNITION

by

Saiful Helmi Abdul Hamid

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:




Mr. Patrick Sebastian
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2007

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Saiful Helmi Abdul Hamid

ABSTRACT

The project is about car number plate recognition. In this project, program needs to be developed that can automatically read the number plate of the vehicles. Car number plate recognition is an image processing technology used to identify vehicles by their plate [7]. It has been used widely in a number of applications such as automation car parking system, security parking system, and automated payment toll. In this project, image processing work will be done by using the image processing toolbox in MATLAB. In order to identify characters form the vehicle's plate, image processing techniques such as extraction, enhancement, and segmentation of certain features need to be implemented for identification of the characters.

ACKNOWLEDGEMENTS

With my sincerest appreciation, I would like to express my utmost gratitude to my supervisor, Mr. Patrick Sebastian for his continuous help, support, motivation and guidance throughout this project.

My heartfelt gratitude and appreciation is extended to my friends Adli Shahrul and Mustafa for contributing their opinions and ideas in this project.

Also thanks to all the people who have taught, comments and helps in this project especially in the MATLAB programming. Thanks to my family for all their support. I sincerely appreciated all their efforts in terms of time and money.

Last but not least, thank you to all the others who is directly or indirectly has contributed to this project.

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES.....	x
CHAPTER 1 INTRODUCTION	1
1.1 Background of Study.....	1
1.2 Problem Statement	1
1.3 Objectives.....	2
CHAPTER 2 LITERATURE REVIEW AND THEORY	3
2.1 Theory	3
2.1.1 Number plate.....	3
2.1.2 Malaysian Car Number Plate	3
2.1.3 MATLAB.....	4
2.1.4 Optical Character Recognition.....	4
CHAPTER 3 METHODOLOGY	5
3.1 Procedure Identification	5
3.2 Image Processing Techniques	6
3.3 Tool	7
3.4 Flow chart for the program.....	8
CHAPTER 4 RESULTS AND DISCUSSION	9
4.1 Discussion	9
4.2 Information on segmentation image.....	9
4.3 Template matching using correlation.....	11
4.3.1 Result and discussion of template matching.....	12
4.4 Recognition of plate using Morphological Character Recognition	13
4.4.1 Binary hit-and-miss operation	13
4.4.2 Implementation of Morphological Character Recognition....	13
4.4.3 Discussion and problem.....	14
4.5 Inverting number plate to solve in displaying duplicated characters	15
4.5.1 Discussion of inverting.....	16
4.6 Issues about template matching.....	17
4.6.1 Threshold value.....	17

4.6.2 Template image.....	17
4.7 Issue about morphological character recognition.....	17
4.8 Comparison of results.....	18
4.9 Using row and column coordinate of each character to arrange the data	19
4.9.1 Arrangement of characters.....	20
4.9.2 Flow chart to arrange the characters	21
CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS	22
5.1 Conclusions	22
5.2 Recommendations	22
REFERENCES.....	23
APPENDICES.....	25
Appendix A NUMBER PLATE.....	26
Peninsular Malaysia.....	26
East Malaysia.....	27
Vanity plates	28
Appendix B TEMPLATE MATCHING	29
Appendix C Morphological character recognition.....	33
Appendix D Coding for two rows	37
Appendix E Coding one row	42

LIST OF TABLES

Table 3.1	Image Processing Techniques that need to be implemented.....	7
Table 4.1	Result between template matching with morphological character	18
Table 4.2	Arrangement of characters	20

LIST OF FIGURES

Figure 3.1 Flow chart for the program	8
Figure 4.4 Character template image (alphabet B)	11
Figure 4.5 Character template image (number 5)	11
Figure 4.6 Number plate image.....	11
Figure 4.7 Plate	12
Figure 4.8 Result of correlation	12
Figure 4.9 Result of correlation after applying threshold	12
Figure 4.10 Number plate	13
Figure 4.11 Result after implementation of Morphological.....	13
Figure 4.12 Result of recognition.....	14
Figure 4.13 Previous plate.....	15
Figure 4.14 After inverting the color of number plate	15
Figure 4.15 Previous matching character.....	15
Figure 4.16 After inverting the character	15
Figure 4.17 Result after inverting	16
Figure 4.18 Coordinate for each character	19
Figure 4.19 Flow chart to arrange the characters.....	21

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Car Number Plate Recognition is a technology of an image processing used to identify vehicles by their number plate. This technology is starting to be used in a number of applications because number plate is a mandatory identifier for vehicles. This technology can be used in applications such as parking automation system, parking security system, and automated payment toll. [7]

Since the number on plates have a standard size and a specification based on each country standard, optical character recognition (OCR) method can be used to recognize the number plate. The idea on this car number plate recognition project is that a camera will take an image of the front or rear of the vehicle. Then, the image processing software will analyze the images and the information will be extracted. The image processing analysis will be done by using MATLAB.

1.2 Problem Statement

From the captured image, area of number plate will be identified. It means that ROI (Region of interest) is the plate number only and the rest will be eliminated. The problem is how to identify the area of number plate. After that, characters in plate will be segmented before the recognition process. In the recognition process, the characters will be recognized whether it is alphabetical or number. The captured image plays an important role. The better the quality of the image, the better the results are.

1.3 Objectives

The objectives of the project are:

- To develop a program that can recognize car plate number by using the image processing toolbox in Matlab
- To use optical character recognition (OCR) techniques to recognize and read the plate number

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Theory

2.1.1 Number plate

Number plate is a vehicle registration plate or known as license plate. This plate actually is a plastic or metal that attached to a vehicle. Usually, it will be attached at front and also at the rear of the vehicle. This plate is required for official identification purpose. The plate is combination of alphabetical and number which is specific for the vehicle.

This alphabetical and numbers is unique to the vehicle and identifies it in government databases by make, model, year, and the name and address of the vehicle's registered owner. In this project, studies need to be done in order to develop a car plate number recognition for Malaysian license plate.

2.1.2 Malaysian Car Number Plate

Vehicle license plate in Malaysia consists of numbers and alphabets. The license plates have white characters on a black background. It follows the following format: ABC 1234.

The first letters at the initial plate indicate the area of registration. It means that it tells where the vehicle comes from and then, followed by up to four digits of numbers. For an example: CAA 1998 is a vehicle registered in Pahang, because it begins with letter C. For plate number in Malaysia, "O" and "I" are not used because they can be confused with "1" and "0". Meanwhile "Z" is used for military only. (*Refer Appendix 1*)

2.1.3 *MATLAB*

MATLAB is an abbreviation of the "MATrix LABoratory". MATLAB is powerful software and a high-level computing language and interactive environment to develop algorithm, data analysis, data visualization, and numeric computation. It was created by the MathWorks. Technical computing problems can be solved faster than any other programming languages such as C, C++, and Fortran.

MATLAB is used in a wide range of application including communications, control design, signal and image processing, computational biology and many more. In this project, the image processing is done by using the Image Processing Toolbox in MATLAB. Add-on toolboxes (collections of special-purpose MATLAB functions) which are available separately extend the MATLAB environment to solve particular cases in certain areas. [9]

2.1.4 *Optical Character Recognition*

OCR is abbreviation of Optical Character Recognition involves computer software designed to convert image of characters or typewritten text into machine-editable text or translate them into standard encoding and represent them in ASCII or Unicode. The process of OCR involves several steps which are extraction, segmentation and classification. [10]

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

Below is the methodology and project works that will be used in order to complete this project:

Literature review

- All information gathered from the literature review as reference will be used to study the car plate number recognition. All the methods that can be used to recognize the plate number is compared with each other in order to choose a suitable method. Literature review is obtained through conference paper, journal, books, and from IEEE and ACM websites.

Image Processing

- All the image processing will be done by using the MATLAB software. The image processing toolbox which is available in the software will help to normalize the image, enhance, segmentation, and finally extract the alphanumeric of the plate number. The method to read the plate number will be done by using the OCR (Optical Character Recognition) since the plates number are same and based on country standard. In the following table shows the image processing techniques in Matlab that would be studied for application in the project.

3.2 Image Processing Techniques

In this project, image processing is used to analyze the image and recognize the car number plate. Since standard number plate is in black and white color, so it will be easier to deal with grayscale image. Then, the image will be converted to binary image for faster image processing. Image analysis requires certain extraction of features to help in identification of the object. The plate number must be extracted from the background. It means that only the plate number is needed and the rest of the picture is eliminated. To identify the plate number, all characters need to be segmented using segmentation techniques. After the segmentation techniques, the object obtained will be identified and analyzed.

Below are the scopes of study for image processing technique:

1. Plate localization – responsible to find and isolate the plate on the picture.
2. Plate orientation and sizing – compensates for the skew of the plate and adjusts the dimensions to the required size.
3. Normalization – adjusts the brightness and contrast of the image.
4. Character segmentation – finds the individual characters on the plates.
5. Optical character recognition.
6. Analysis – check characters and positions against country specific rules.

Table 3.1 Image Processing Techniques that need to be implemented

No.	Technique	Function(s)
1.	Plate localization	Find and isolate plate number from image Define region of interest
2.	Resizing	Adjust the plate to the required size
3.	Enhancement	Adjust the brightness and contrast Remove noise from image
4.	Segmentation	Find individual characters on plate
5.	Recognition	Recognize the segmented character

3.3 Tool

Image processing toolbox in Matlab is the major tool that will be using through out this project. Equipments that are needed in this project are camera. For the camera, it is better to use a high resolution camera because the requirement of high quality images. In this project, a camera digital is used rather than webcam. Camera digital used can capture a high quality image because the resolution for the camera is 2032x1520 (3 Mega pixels).

3.4 Flow chart for the program

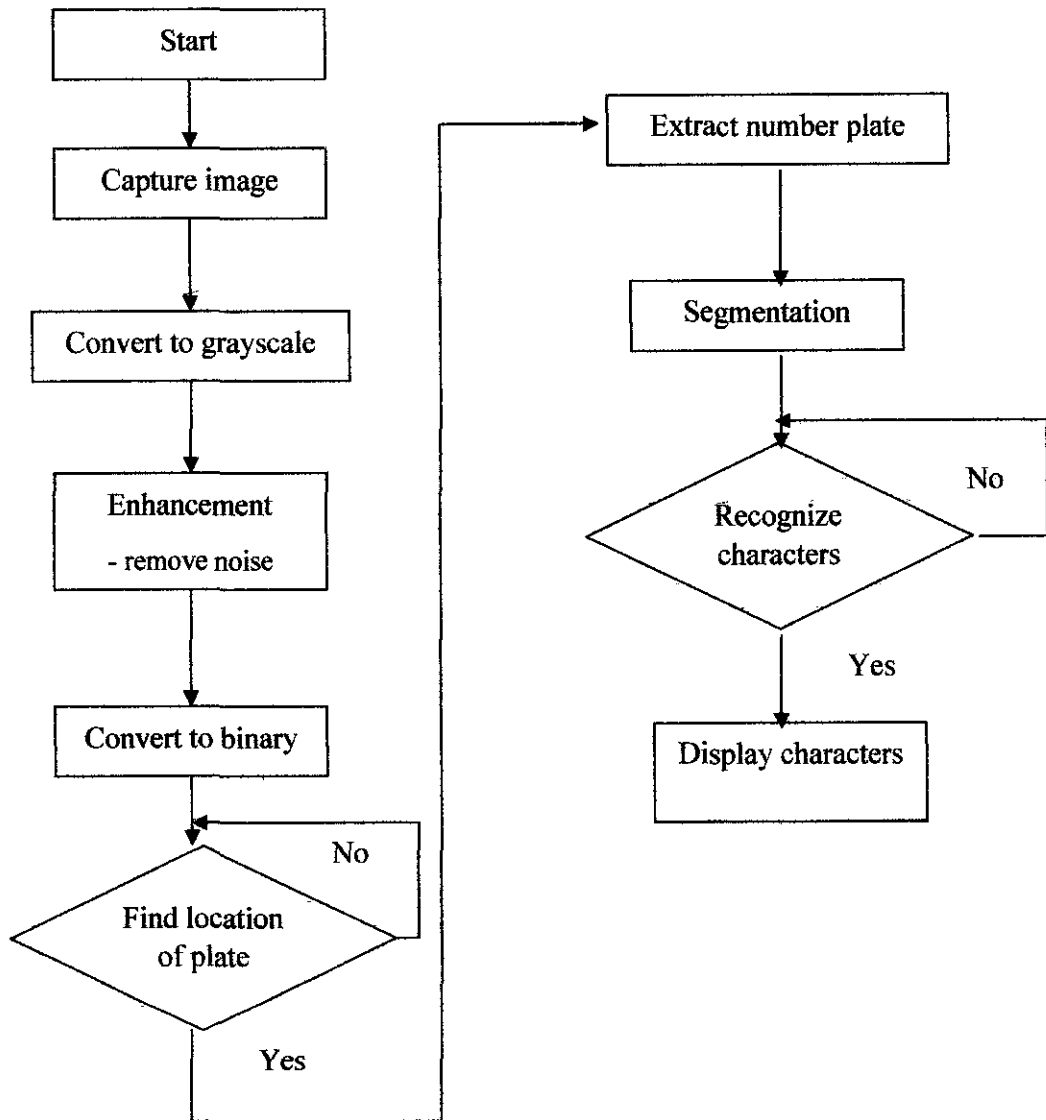


Figure 3.1 Flow chart for the program

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Discussion

In this chapter, the discussion will cover:

- 1) Information on segmentation image
- 2) Template matching using correlation to recognize the character on the plate number
- 3) Morphological Character Recognition
- 4) Using row and column coordinate to arrange the characters

4.2 Information on segmentation image

All the information available is gathered and reviewed. Basically, image segmentation is an image algorithm that will divide and subdivides the image into constituent areas/regions so that only the interest object can be identified and analyzed. Image segmentation is also to separate objects from background. This analysis process starts by finding which pixels belong to each object or character. [9]

Three principal concepts are generally applied in segmentation methods.

1. Edge detection

- Different structures or different object/character can be separated by detecting the discontinuities in the image. It means that the image is separated into segment if there is no continuity of the objects.
- For detecting edge, it is like detecting the boundaries of objects/characters in an image. Edge detection is used to identify the edges in an image whereas edge is a curve that follows a path of rapid change in image intensity. In the MATLAB, *edge function* is used to find the edge [4].

2. Threshold

- This principle differentiates between background and foreground of the objects/characters. This approach is based on the intensity of the pixels. If pixels whose intensities is lower than the threshold could be considered part of the background meanwhile for the pixels with intensities larger than the threshold could be considered part of the foreground objects.

3. Region processing

- This region-based segmentation methods operate with a set of seed pixels and then extend to neighboring pixels that have similar properties

4.3 Template matching using correlation

Among method of recognizing the characters is template matching using correlation

Basically, this technique is done by applying the correlation between number plate images with the character template image which is used for recognition [10].

Character template image is an image of number or alphabetical that used for recognition.

Example:



Figure 4.4 Character template image (alphabet B)



Figure 4.5 Character template image (number 5)



Figure 4.6 Number plate image

For correlation, the equation can be stated as

$$h(x,y) = f(x,y) * g^*(x,y)$$

where $h(x,y)$ is the result of the correlation

$f(x,y)$ can be represented as a number plate image

$g^*(x,y)$ can be represented as character template image

4.3.1 Result and discussion of template matching

The plate will be correlated with alphabet or numeral template. Basically, the first three characters are alphabets and it will be correlated with all 26 alphabet templates. After that, correlation between the 10 numeral templates will be done. In this result, template image of alphabet B (Figure 4.4) is correlated with the plate.



Figure 4.7 Plate

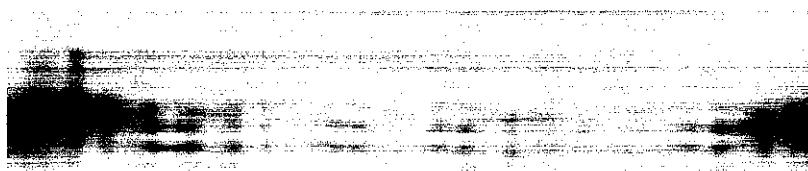


Figure 4.8 Result of correlation

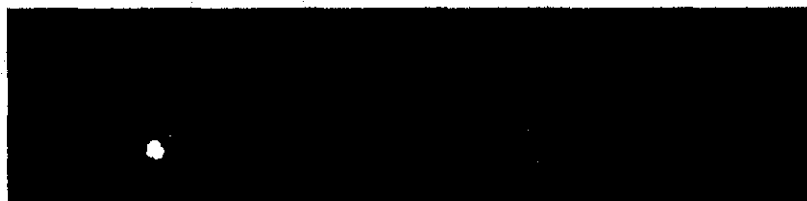


Figure 4.9 Result of correlation after applying threshold

Figure 4.9 is the result of correlation after applying threshold. Threshold value is the value that less than maximum value of the correlated result. The dot in the figure 4.9 shows the location of character B.

Although the white dot indicates the location of alphabet B, but the location of white dot is not at the centre of the character. So, it is hard to use this property to identify characters if the location of white dot exceeds the boundaries area of the characters.

4.4 Recognition of plate using Morphological Character Recognition

This technique has been studied and tested with the plate number. It can be used to identify characters in the plate number. Morphological operations like dilation and hit-or-miss operation are used to recognize characters. Morphological operation has been performed with the plate image to see the result.

4.4.1 Binary hit-and-miss operation

Syntax: $BW2 = bwhitmiss(BW1, SE1, SE2)$

It performs the hit-and-miss operation defined by the structuring elements SE1 and SE2. The hit-and-miss operation preserves pixels whose neighborhoods match the shape of SE1 and don't match the shape of SE2. SE1 and SE2 can be flat structuring element objects, created by `strel`, or neighborhood arrays. The neighborhoods of SE1 and SE2 should not have any overlapping elements.[8]

4.4.2 Implementation of Morphological Character Recognition

Morphological character recognition used binary hit-and-miss operation to recognize the characters. It used template image (Figure 4.4 and Figure 4.5) to be matched with the number plate. The hit-and-miss operation preserves pixels whose neighborhoods match the shape of template image. In other word, it is like finding in the number plate which area matches the shape of template image.



Figure 4.10 Number plate



Figure 4.11 Result after implementation of Morphological

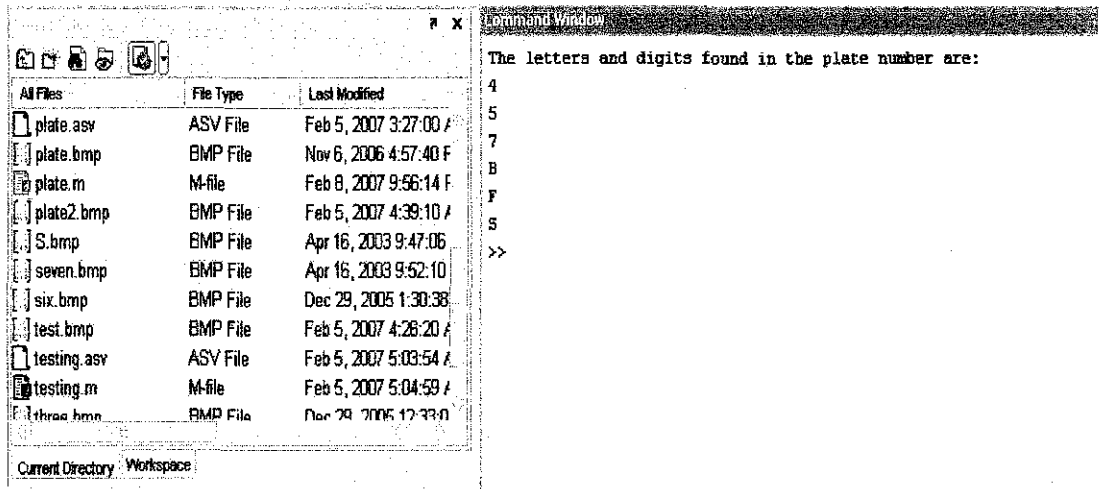


Figure 4.12 Result of recognition

4.4.3 Discussion and problem

For Figure 4.12, it is the result after implementation of morphological operation between template image alphabet 'B' (Figure 4.4) with number plate. The white dot indicated the location of character 'B' in the plate. The location of white dot is almost at the centre of the character 'B'.

The result obtained shows that it can recognize all the characters in the plate number. But the problem faced is the technique can not display 2 same characters that exist in the plate number. Like example number plate of 'BFS 5475', it can recognize all the numbers which are 4, 5 and 7 but display the number '5' only once instead it should be displayed twice. Other than that, it displays all the letters and numbers out of sequence. Supposedly, it should display the letters first and then followed by numbers. Some modification needs to be made to overcome the problem.

4.5 Inverting number plate to solve in displaying duplicated characters

The method used to display double characters in the number plate is by inverting the color of previous plate number. Other than that, all the surrounding except the characters must be filled with black color. The same goes to matching characters. It will be inverted from the previous matching character.



Figure 4.13 Previous plate



Figure 4.14 After inverting the color of number plate



Figure 4.15 Previous matching character



Figure 4.16 After inverting the character

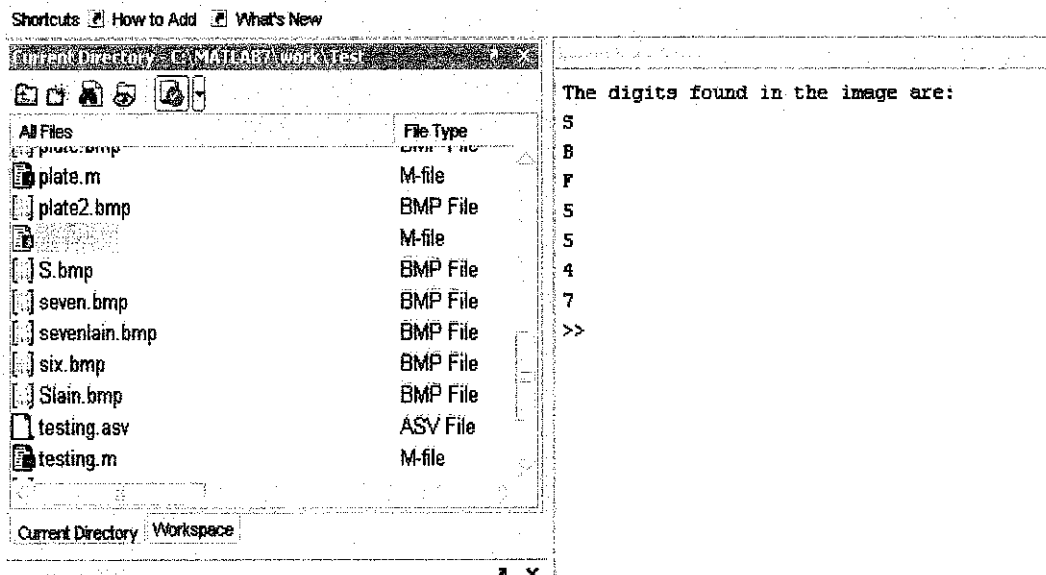


Figure 4.17 Result after inverting

4.5.1 Discussion of inverting

The inverting color of plate helps the process to recognize the data. By inverting the color and fill the surrounding with black, it is considered as tweaking to find the right template. It is because this template only can recognize those characters whose template is available to it. This technique is easy to implement but only the character templates that are same with the plate can be recognized.

4.6 Issues about template matching

There are some problem faced which are:

1. Threshold value
2. Template image

4.6.1 Threshold value

For template matching, correlation is done between template images with number plate. In this case, a number plate will be correlated with all alphabets from A to Z and also with all numbers which are 0 to 9. In the result after applying correlation, there will be a highest point that indicates where correlation happen the best. Threshold value needs to be determined in order to find that highest peak. So, a good threshold value is needed. It is quite hard to determine the threshold value since correlations of each template images with number plate have different peak points.

4.6.2 Template image

In this technique, only characters that exist in the number plate can be correlated. Like example if the plate is 'WED 49', only the template images of 'E', 'D', 'W', '4', and '9' can be correlated. If other character like 'A' is correlated with the plate, the presence of character A will also be displayed in the result.

4.7 Issue about morphological character recognition

The only problem with this technique is the data results are out of sequence. If the number plate is 'BFS 5475', the result will display 'SBF 5547'. It shows that the arrangement of character is out of order. To solve this problem, row and column coordinate characteristic will be used. (Refer 4.9)

4.8 Comparison of results

Table 4.1 Result between template matching with morphological character

Template matching	Morphological character recognition
Actual plate : WED 49 Result : AWED 49	Actual plate: WED 49 Result: WED 49
Actual plate: TAL 534 Result: TWWAL 534	Actual plate: TAL 534 Result: TAL 534
Actual plate: WCJ 807 Result: WCJ 9807	Actual plate: WCJ 807 Result: WCJ 807

4.9 Using row and column coordinate of each character to arrange the data

The column and row information needs to be used to display the data correctly.

A character with smaller number of row will be displayed first. If coordinate of the rows are same for each characters then it will be arranged using the column coordinate.

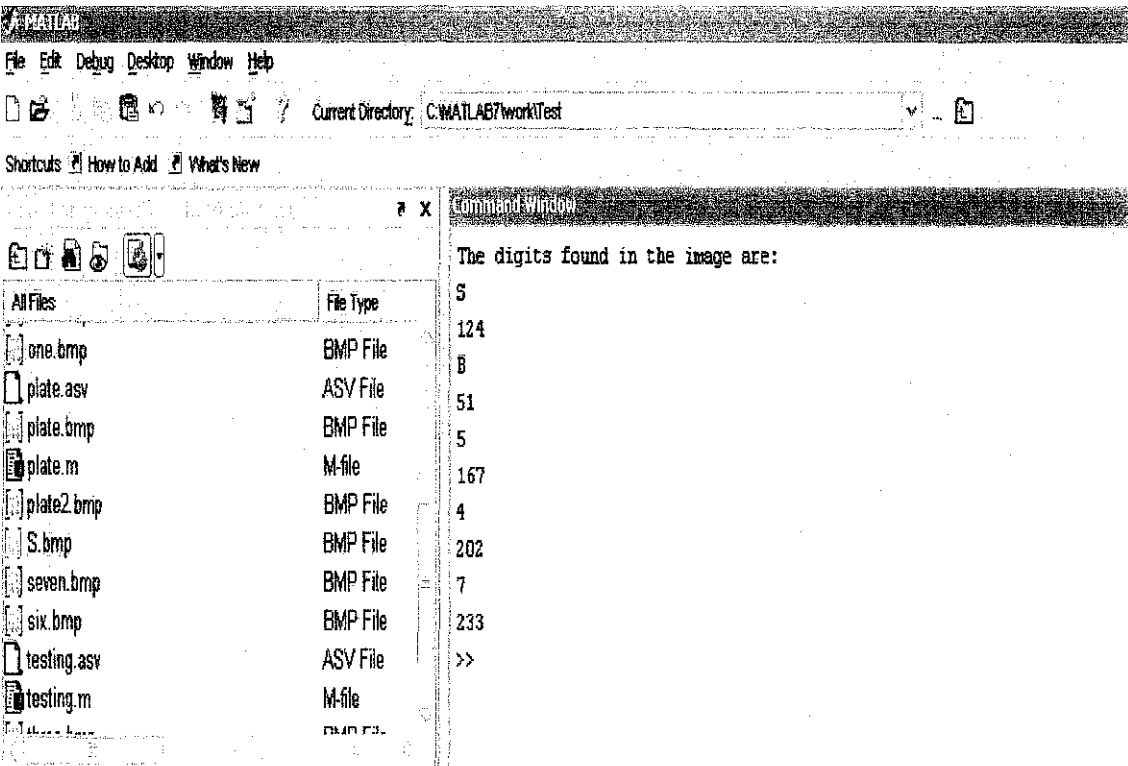


Figure 4.18 Coordinate for each character

The position of each character is managed to identify. The location of each characters represent by its column. From the above image, the locations of characters are:

Character of 'S' is at column 124

Character of 'B' is at column 51.

Character of 'F' is at column 83.

Character '5' at column 167 and 261

Character '4' at column 202

Character '7' at column 233

4.9.1 Arrangement of characters

The characters should be arranged as below:

Table 4.2 Arrangement of characters

Column coordinate	Character
51	B
83	F
124	S
167	5
202	4
223	7
261	5

4.9.2 Flow chart to arrange the characters

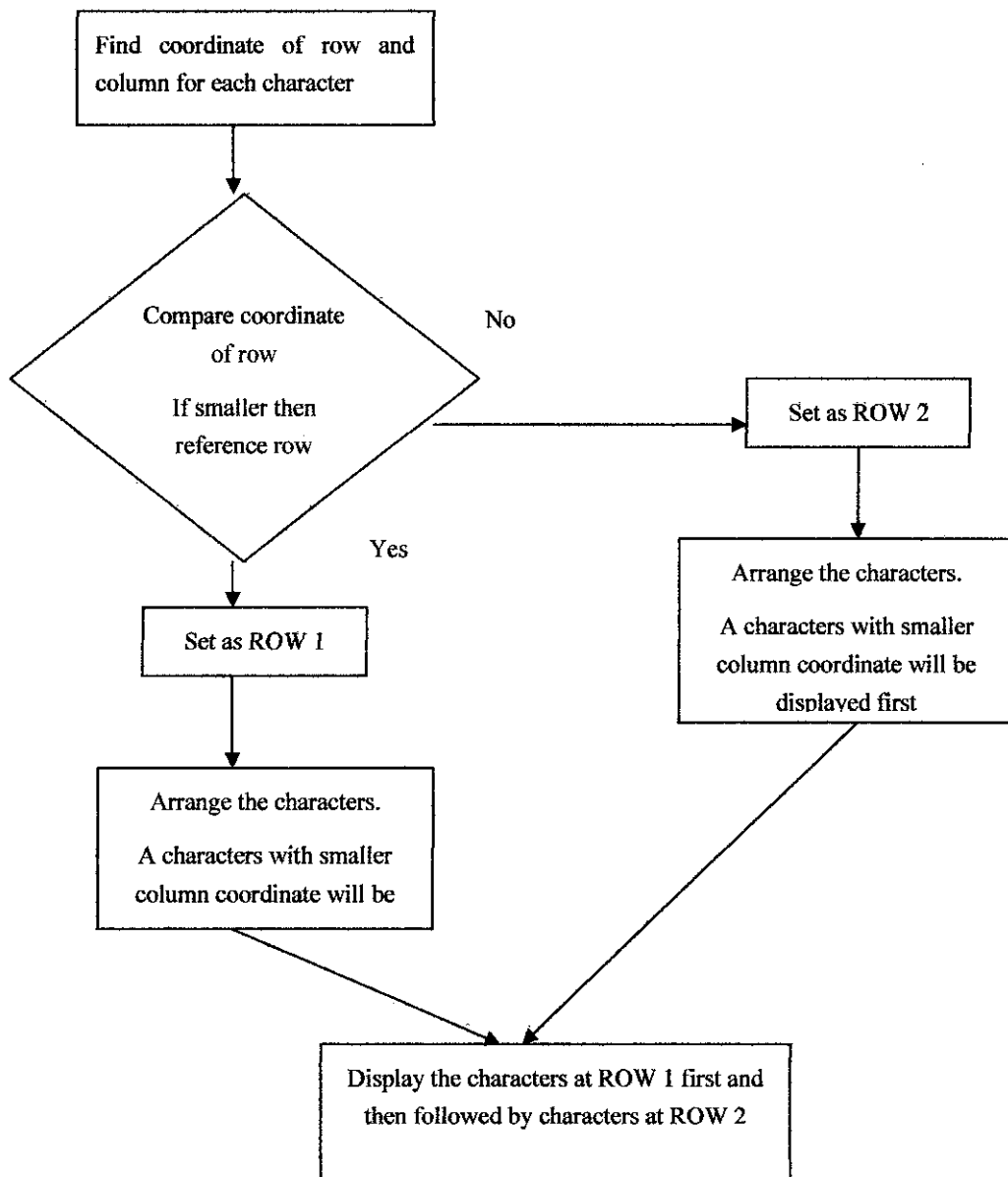


Figure 4.19 Flow chart to arrange the characters

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this project, a program is expected to be developed that can recognize car number plate by using the image processing techniques. This project is targeted can be used in any applications such as for security, control access, and automation system. The method which is morphological character recognition is used to recognize the characters since it has better performance rather than template matching. Other than that, this project used black and white image for faster image processing. The camera digital is used rather than webcam because it provides better resolution for the image. The purpose of OCR (Optical Character Recognition) is to classify optical pattern that is equivalent to alphabets, numbers or other characters. [10]

5.2 Recommendations

There are some recommendations that can be made to improve this project. The pan and tilt platform can be built in order to move the camera to the left and right. The basic operation of the platform is, when the specific region to detect the presence of the coming vehicles has been triggered, the camera will move a little bit to the left/or right before capturing the image. For the pan platform, a servomotor is required in order to move the camera to the left or right. Other than that, high speed recognition can be done via a high speed camera. High speed camera is used because of the requirement in high quality images. Besides, the program can be linked up with database which contains some information about the vehicle such as model, year, and the name and address of the vehicle's registered owner.

REFERENCES

- [1] E. Rendbn, L. Salgado, J.M. Menhdez and N. Garcia, 1994 “A software Architecture for Real-time Parallel Image Processing”.
- [2] J. Barosso et al, 1997, Number plate reading using Computer Vision.
- [3] Mori, Nishida, Yamada, 1999, Optical Character Recognition, “A Wiley-Interscience publication”
- [4] Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall
- [5] R.Parisi, E.D.Di Claudio, G.Lucarelli and G.Orlandi, Car Plate Recognition by Neural Network and Image Processing.
- [6] P.Comelli, P. Ferragina, M. Notturmo and F. Stabile, November 1995 “Optical Recognition of Motor Vehicle License Plate” IEEE Trans On Vehicular Technology.
- [7] Yoram Hofman, R&D Manager Hi-Tech Solution, May 2004 “ License Plate Recognition”
- [8] Stanley J. Reeves, Dec 1997 “ Matlab for Digital Image Processing”
- [9] R.C. Gonzalez, Richard E Woods, Steven L Eddins, “Digital Image Processing Using Matlab”

[10] Sabeen, "Number Plate Recognition"

[11] Dr. Scott E Umbaugh, July 2001, Computer Vision and Image Processing Laboratory, Electrical and Computer Engineering Department of Southern Illinois University at Edwardsville

APPENDICES

APPENDIX A

NUMBER PLATE

Peninsular Malaysia

Vehicle license plates used in Peninsular Malaysia start with a letter of the alphabet. Vehicles registered in the various states begin with specific letters as follows:

- **A:** Perak
- **B:** Selangor, including plates registered in Kuala Lumpur before the city is a federal territory
- **C:** Pahang
- **D:** Kelantan
- **J:** Johor
- **K:** Kedah, including Langkawi (**KV**)
- **M:** Malacca
- **N:** Negeri Sembilan
- **P:** Penang
- **R:** Perlis
- **T:** Terengganu
- Vehicles registered in the federal territories:
 - **L:** Labuan
 - **PUTRAJAYA** as starting text: Putrajaya
 - **W:** Kuala Lumpur (Up to 1957, W was the code for Province Wellesley).

Peninsular Malaysia Motor Dealer's (Trade) plates are white on a blue ground using the format L NNN L, where the first letter is the state code and the final letter is a serial, as are the numbers.

East Malaysia

Vehicles registered in the states of Sarawak and Sabah are allocated vehicle number plates commencing with the letters Q (Sarawak) or S (Sabah). Then follows the regional code and a serial number - when 9999 is reached a serial letter is used, in alphabetical order, to augment. In Sabah this serial letter follows the serial number (SA 1234 A), and in Sarawak it follows the regional code (QKA 1234)

- **Q: Sarawak**
 - **QA and QK:** Kuching
 - **QB:** Sri Aman
 - **QC:** Kota Samarahan
 - **QL:** Limbang
 - **QM:** Miri
 - **QP:** Kapit
 - **QR:** Sarikei
 - **QS:** Sibu
 - **QT:** Bintulu
 - **QSG:** Government
- **S: Sabah**
 - **SA:** Kota Kinabalu and Kota Belud
 - **SB:** Beaufort
 - **SD:** Lahad Datu
 - **SK:** Kudat
 - **SS:** Sandakan
 - **ST:** Tawau
 - **SU:** Keningau
 - **SG:** Government

Vanity plates

Vanity plates, *i.e.* plates using special, distinctive prefixes, are available at extra cost. These special prefixes may denote the brand of the car (such prefixes are often used, for example, on Proton and Perodua cars). Among the more commonly used special prefixes are:

- **WAJA:** Issued for Proton Waja cars.
- **Satria:** Issued for Proton Satria cars.
- **NAZA:** Issued for Naza vehicles.
- **SUKOM:** Issued only during the 1998 Commonwealth Games, which was held in Kuala Lumpur at that year.
- **XIII NAM:** Issued only during the 2003 NAM Summit which was held in Kuala Lumpur at that year.
- **X OIC:** Issued only during the 2003 OIC Summit which was held in Kuala Lumpur at that year.
- **XI ASEAN:** Issued only during the 2005 ASEAN Summit which was held in Kuala Lumpur at that year.
- **BAMbee:** Issued only during the 2000 Thomas and Uber Cup which was held in Kuala Lumpur at that year.

APPENDIX B

TEMPLATE MATCHING

Coding

```
clc;
% read the plate number and template images
bw=imread('NPLATE2.bmp'); %reading image of a number plate.
a=imread('B.bmp');      %reading image of a character.
b=imread('F.bmp');
c=imread('S.bmp');
d=imread('4.bmp');
e=imread('5.bmp');
f=imread('7.bmp');

figure(1), imshow(bw),title('Image of number plate'); %Displaying image of number plate.
figure(2), imshow(e); title('Image of character'); %Displaying image of character.
selected = bw;
% figure(3), imshow(selected);title('selected image');

%Now correlation between image of character and image of number plate
%will be performed.
%which can be computed by first rotating the image
%of character by 180 degree
%and then convolution of character image and number
%plate is performed.
%which is implemented by using frequency domain fft

% result=real(iff2(fft2(selected,70,324) .* fft2(rot90(a,2),70,324)));
result=real(iff2(fft2(selected,80,330) .* fft2(rot90(a,2),80,330)))
result1=real(iff2(fft2(selected,80,330) .* fft2(rot90(b,2),80,330)))
result2=real(iff2(fft2(selected,80,330) .* fft2(rot90(c,2),80,330)))
result3=real(iff2(fft2(selected,80,330) .* fft2(rot90(d,2),80,330)))
result4=real(iff2(fft2(selected,80,330) .* fft2(rot90(e,2),80,330)))
result5=real(iff2(fft2(selected,80,330) .* fft2(rot90(f,2),80,330)))
```

```

figure(4), imshow(result,[],),title('Result of Correlation');
maximum = max(result(:));
maximum1 = max(result1(:));
maximum2 = max(result2(:));
maximum3 = max(result3(:));
maximum4 = max(result4(:));
maximum5 = max(result5(:));

subplot(2,1,1, 'B');plot (result)% B
grid on
% subplot(2,1,2, '5');plot (result4)%5
% grid on

% set the threshold value to find the highest peak
thresh = maximum - 10;%you have to use a threshold which is little less than max.
thresh1 = maximum1 - 1;
thresh2 = maximum2 - 1;
thresh3 = maximum3 - 1;
thresh4 = maximum4 - 1;
thresh5 = maximum5 - 1;

resulta=result > thresh;
resultb=result1 > thresh1;
resultc=result2 > thresh2;
resultd=result3 > thresh3;
resulte=result4 > thresh4;
resultf=result5 > thresh5;

max(result(:))
figure(5), imshow(result > thresh),title('Result of Correlation after applying threshold for B ');

```

```

% which pixels with value 1
for j=1:324
    for i=1:70

        if resulta(i,j) == 1
            pixel(1,j)= resulta(i,j);
            disp('B');
            %     disp('location of character at');
            %     disp(num2str(j));
            %     count=count+1;
        end

        if resultb(i,j) == 1
            pixel(1,j) = resultb(i,j);
            disp('F');
            %     disp('location of character at');
            %disp(num2str(j));
            %     count=count+1;
        end

        if resultc(i,j) == 1
            pixel(1,j) = resultc(i,j);
            disp('S');
            %     disp('location of character at');
            %     disp(num2str(j));
        end

        if resultd(i,j) == 1

            pixel(1,j)= resultd(i,j);
            disp('4');
            %     disp('location of character at');
            %     disp(num2str(j));
            %     count=count+1;
        end

        if resulte(i,j) == 1

            pixel(1,j)= resulte(i,j);
            disp('5');
            %     disp('location of character at');
            %     disp(num2str(j));
            %     count=count+1;
        end
    end
end

```



```

if resultf(i,j) == 1

    pixel(1,j)= resultf(i,j);
    disp('7');
%    disp('location of character at');
%    disp(num2str(j));
%    count=count+1;
end

end

end

```

APPENDIX C

MORPHOLOGICAL CHARACTER RECOGNITION

Coding

```
%-----  
% Recognition Part  
%-----  
  
clc;  
Z=imread('car.bmp'); % Read the plate image  
  
% Read the number template images  
A= imread ('zero.bmp');  
B= imread ('one.bmp');  
C= imread ('two.bmp');  
D= imread ('three.bmp');  
E= imread ('fourlain.bmp');  
F= imread ('fivelain.bmp');  
G= imread ('six.bmp');  
H= imread ('sevenlain.bmp');  
I= imread ('eight.bmp');  
J= imread ('nine.bmp');  
  
%Read the alphabets template image  
alpha = imread ('Blain.bmp');  
alpha1 = imread ('Flain.bmp');  
alpha2 = imread ('Slain.bmp');  
%SE 2  
  
SE = strel('square',32);  
  
% Perform imdilate for numbers  
K=imdilate(A,SE);A2=K-A;  
L=imdilate(B,SE);B2=L-B;  
M=imdilate(C,SE);C2=M-C;  
N=imdilate(D,SE);D2=N-D;
```

```

O=imdilate(E,SE);E2=O-E;
P=imdilate(F,SE);F2=P-F;
Q=imdilate(G,SE);G2=Q-G;
R=imdilate(H,SE);H2=R-H;
S=imdilate(I,SE);I2=S-I;
T=imdilate(J,SE);J2=T-J;

%Perform imdilate for alphabet
beta = imdilate(alpha ,SE); ma = beta- alpha;
beta1 = imdilate(alpha1,SE); mb = beta1-alpha1;
beta2 = imdilate(alpha2,SE); mc = beta2-alpha2;

disp('The number plate of the car is:');

%-----
%Hit or Miss operation
%-----

result = bwhitmiss(Z,alpha,ma); % B
result1 = bwhitmiss(Z,alpha2,mc);%S
result2 = bwhitmiss(Z,alpha1,mb);%F
result3= bwhitmiss(Z,E,E2); %4
result4= bwhitmiss(Z,F,F2);%5
result5= bwhitmiss(Z,H,H2);%7

fresult= result + result1 + result2 + result3 + result4 + result5;
imview(fresult)

% imview(result)
% imview(result1)
% imview(result2)
% imview(result3)
% imview(result4)
% imview(result5)

```

```

% arrangement of character
for j=1:324
    for i=1:70

        if result(i,j) == 1
%           flag=1;pixel(1,j)=result1(i,j);
            disp('B');

            columna = num2str(j);
            position = str2num(columna);
%           disp(num2str(j));

        elseif result1(i,j) == 1
            disp('S');
            columnb = num2str(j);
            position1 = str2num(columnb);
%           disp(num2str(j));

        elseif result2(i,j) ==1
            disp('F');
            columnc = num2str(j);
            position2 = str2num(columnc);
%           disp(num2str(j));

        elseif result3(i,j) == 1
            disp('4');
            columnd = num2str(j);
            position3 = str2num(columnd);
%           disp(num2str(j));

        elseif result4(i,j) == 1
            disp('5');

            columne = num2str(j);
            position4 = str2num(columne);
%           disp(num2str(j));

        elseif result5(i,j) == 1
            disp('7');
            columnf = num2str(j);

```

```

        position5 = str2num(columnf);
    %    disp(num2str(j));
    %    count=count+1;
    end

end

end

% location = [ position position1 position2 position3 position4 position5 ]
% location1= sort(location)

imview (Z)

```

APPENDIX D

CODING FOR TWO ROWS

Plate: BGK 2539

```
clc;
% Read the car image
%-----
RGB = imread('car.jpg');
imview(RGB);
% imfinfo('car.jpg')

% Convert RGB to gray
%-----
car1 = rgb2gray(RGB);
imwrite(car1,'car1.bmp'); % save image
imview(car1);
% imfinfo('car1.bmp')

% Convert to bw
%-----
car2 = im2bw(car1,0.4);
figure,imshow(car2);title('Binary Image');

% Choose the number plate area
plate = imcrop(car2); % choose the area
imwrite(plate,'plate.bmp');

% display sub images
figure, imshow(plate)

%resize image
new_plate1 = imresize(plate,[300 324]);
imwrite(new_plate1,'new plate1.bmp');
figure, imview(new_plate1)

% new_plate = imread('new plate.bmp');
```

```

%% % imview(new_plate)

%-----
% Recognition Part
%-----

clc;

Z=imread('new_plate.bmp'); % Read the plate image

% Read the number template images
A= imread ('zero.bmp');
B= imread ('one.bmp');
C= imread ('2.bmp');
D= imread ('3.bmp');
E= imread ('4.bmp');
F= imread ('5.bmp');
G= imread ('six.bmp');
H= imread ('seven.bmp');
I= imread ('eight.bmp');
J= imread ('9.bmp');

%Read the alphabets template image
alpha = imread ('G.bmp');
alpha1 = imread ('B.bmp');
alpha2 = imread ('K.bmp');
%SE 2

SE = strel('square',85);

% Perform imdilate for numbers
K=imdilate(A,SE);A2=K-A;
L=imdilate(B,SE);B2=L-B;
M=imdilate(C,SE);C2=M-C;
N=imdilate(D,SE);D2=N-D;
O=imdilate(E,SE);E2=O-E;
P=imdilate(F,SE);F2=P-F;
Q=imdilate(G,SE);G2=Q-G;
R=imdilate(H,SE);H2=R-H;
S=imdilate(I,SE);I2=S-I;
T=imdilate(J,SE);J2=T-J;

```

```

%Perform imdilate for alphabet
beta = imdilate(alpha,SE); ma = beta-alpha;
beta1 = imdilate(alpha1,SE); mb = beta1-alpha1;
beta2 = imdilate(alpha2,SE); mc = beta2-alpha2;

disp('The digits found in the image are:');

%-----
%Hit or Miss
%-----

result = bwhitmiss(Z,alpha,ma); % G
result1 = bwhitmiss(Z,alpha2,mc); %K
result2 = bwhitmiss(Z,alpha1,mb); %B
result3= bwhitmiss(Z,E,E2); %4
result4= bwhitmiss(Z,F,F2); %5
result5= bwhitmiss(Z,C,C2); %2
result6= bwhitmiss(Z,J,J2); %9
result7= bwhitmiss(Z,D,D2); %3

fresult= result + result1 + result2 + result3 + result4 + result5 + result6 + result7;
imview(fresult)

% imview(result)
% imview(result1)
% imview(result2)
% imview(result3)
% imview(result4)
% imview(result5)

```



```

% arrang character
for j=1:324
    for i=1:150 % for upper part

        if result(i,j) == 1
            disp('G');
            columna = num2str(j);
            position = str2num(columna);
%            disp(num2str(j));

        elseif result1(i,j) == 1
            disp('K');
            columnb = num2str(j);
            position1 = str2num(columnb);
%            disp(num2str(j));

        elseif result2(i,j) == 1
            disp('B');
            columnc = num2str(j);
            position2 = str2num(columnc);
%            disp(num2str(j));
        end
    end
end

for j=1:324
    for i=150:300 % for lower part (324x300)

        if result3(i,j) == 1
            disp('4');
            columnd = num2str(j);
            position3 = str2num(columnd);
%            disp(num2str(j));

        elseif result4(i,j) == 1
            disp('5');

            columne = num2str(j);
            position4 = str2num(columne);

```

```

%         disp(num2str(j));

elseif result5(i,j) == 1
    disp('2');
    columnnf = num2str(j);
    position5 = str2num(columnnf);
%     disp(num2str(j));
%     count=count+1;

elseif result6(i,j) == 1
    disp('9');
    columnnf = num2str(j);
%     position6 = str2num(columnng);
%     disp(num2str(j));
%     count=count+1;

elseif result7(i,j) == 1
    disp('3');
    columnng = num2str(j);
end
end
end

% location = [ position position1 position2 position3 position4 position5 ]
% location1= sort(location)

imview (Z)

```

APPENDIX E

CODING ONE ROW

Plate: LA 428

```
clc;
% Read the car image
%-----
RGB = imread('car.jpg');
imview(RGB);
% imfinfo('car.jpg')

% Convert RGB to gray
%-----
car1= rgb2gray(RGB);
imwrite(car1,'car1.bmp'); % save image
imview(car1);
% imfinfo('car1.bmp')

% Convert to bw
%-----
car2=im2bw(car1,0.6);
figure,imshow(car2);title('Binary Image');

% Choose the number plate area
plate = imcrop(car2); %
imwrite(plate,'plate.bmp');

% display sub images
figure, imshow(plate)

%resize image
new_plate=imresize(plate,[70 324]);
imwrite(new_plate,'new plate.bmp');
figure, imview(new_plate)
```

```

%-----
% Recognition Part
%-----

clc;

Z=imread('new plate.bmp'); % Read the plate image


% Read the number template images
A= imread ('0.bmp');
B= imread ('one.bmp');
C= imread ('2.bmp');
D= imread ('three.bmp');
E= imread ('4.bmp');
F= imread ('fivelain.bmp');
G= imread ('six.bmp');
H= imread ('7.bmp');
I= imread ('8.bmp');
J= imread ('9.bmp');


%Read the alphabets template image
alpha = imread ('A.bmp');
alpha1 = imread ('L.bmp');
alpha2 = imread ('Slain.bmp');
%SE 2

SE = strel('square',50);


% Perform imdilate for numbers
K=imdilate(A,SE);A2=K-A;
L=imdilate(B,SE);B2=L-B;
M=imdilate(C,SE);C2=M-C;
N=imdilate(D,SE);D2=N-D;
O=imdilate(E,SE);E2=O-E;
P=imdilate(F,SE);F2=P-F;
Q=imdilate(G,SE);G2=Q-G;
R=imdilate(H,SE);H2=R-H;
S=imdilate(I,SE);I2=S-I;
T=imdilate(J,SE);J2=T-J;

```

```

%Perform imdilute for alphabet
beta = imdilute(alpha,SE); ma = beta- alpha;
beta1 = imdilute(alpha1,SE); mb = beta1-alpha1;
beta2 = imdilute(alpha2,SE); mc = beta2-alpha2;

disp('The number plate is:');

%-----
%Hit or Miss
%-----

result = bwhitmiss(Z,alpha,ma); % A
result1 = bwhitmiss(Z,alpha1,mb);%L
result2 = bwhitmiss(Z,alpha2,mc);%S
result3= bwhitmiss(Z,E,E2); %4
result4= bwhitmiss(Z,F,F2);%5
result5= bwhitmiss(Z,H,H2);%7
result6= bwhitmiss(Z,J,J2);%9
result7= bwhitmiss(Z,A,A2);%0
result8= bwhitmiss(Z,I,I2);%8
result9= bwhitmiss(Z,C,C2);%2

fresult= result + result1 + result2 + result3 + result4 + result5 + result6 + result7 + result8 + result9;
imview(fresult)

% imview(result)
% imview(result1)
% imview(result2)
% imview(result3)
% imview(result4)
% imview(result5)

```

```

% arrange characters
for j=1:324
    for i=1:70

        if result(i,j) == 1
%            flag=1;pixel(1,j)=result1(i,j);
            disp('A');

            columna = num2str(j);
            position = str2num(columna);
%            disp(num2str(j));

        elseif result1(i,j) == 1
            disp('L');
            columnb = num2str(j);
            position1 = str2num(columnb);
%            disp(num2str(j));

        elseif result2(i,j) ==1
            disp('S');
            columnc = num2str(j);
            position2 = str2num(columnc);
%            disp(num2str(j));

        elseif result3(i,j) == 1
            disp('4');
            columnd = num2str(j);
            position3 = str2num(columnd);
%            disp(num2str(j));

        elseif result4(i,j) == 1
            disp('5');

            columne = num2str(j);
            position4 = str2num(columne);
%            disp(num2str(j));

        elseif result5(i,j) == 1
            disp('7');
            columnf = num2str(j);

```

```

        position5 = str2num(columnf);
    %    disp(num2str(j));
    %        count=count+1;

    elseif result6(i,j) == 1
        disp('9');
        columng = num2str(j);
    %        position6 = str2num(columng);
    %    disp(num2str(j));
    %        count=count+1;

    elseif result7(i,j) == 1
        disp('0');
        columnh = num2str(j);

    elseif result8(i,j) == 1
        disp('8');
        columnh = num2str(j);

    elseif result9(i,j) == 1
        disp('2');
    end
end
end

% location = [ position position1 position2 position3 position4 position5 ]
% location1= sort(location)

imview (Z)

```